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Use of otolith length and weight in age estimations of the kingsoldier bream, *Argyrops spinifer*, in the Persian Gulf

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Abstract: Fifty-four specimens of the kingsoldier bream, Argyrops spinifer (Forsskal, 1775) from coastal waters of the Persian Gulf, in Bushehr Province, were aged by otolith readings to assess the suitability of using otolith length/weight for age estimation in this fish. Otolith length and weight increased along with an increase in length and age of the fish. The relationship between fish length (TL) and otolith weight (OW) was as $OW=0.007TL^{-0.79}$ ($r^2=0.90$), between fish age (t) and otolith length (OL) as $OL=5.576\ (t)^{0.346}$ ($r^2=0.88$), between fish age (t) and otolith weight (OW) as $OW=0.03\ (t)^{0.837}$ ($r^2=0.91$) and between fish length (TL) and otolith length (OL) as $OL=1.125\ (TL)^{0.644}$ ($r^2=0.92$). Thus, these parameters could be readily used in age determination of A. spinifer. The proportion of average otolith weight to fish total length which partly shows the growth rate, was assessed as 0.005.

Keywords: Ageing, Otolith, Perciformes, Persian Gulf, Sagitta, Sparidae

Introduction

In most fishes, otoliths could be used for age determination (Anderson et al. 1992; Horn & Sullivan 1996; Newman et al. 2000; Strelcheck et al. 2003) and its reliability has been confirmed by radiometry (Smith et al. 2011). Also, the age composition of a stock is a basic parameter used in stock assessment models in fisheries management (Begg et al. 1999, 2005). Usually, in bony fishes, age is estimated by counting annuli on bony structures such as otoliths, scales, vertebrae, opercula, fin rays and spines (Anderson et al. 1992; DeVries & Frie 1996). Otoliths are calcium carbonate structures which lie in the inner ear and play important roles in hearing and equilibrium (Gauldie 1988). Due to their continual growth and specific shape, otoliths are used for aging (Gauldie 1994, Karlou-Riga 2000), stock identification (Cardinale et al. 2004), ecomorphological, archaeological and paleontological studies (Van Slyke 1998; Torres et al. 2000; Carpenter et al. 2003; Volpedo & Echeverria 2003) or in the stomach contents of predators, for dietary item identifications (Cottrell et al. 1996). However, several physiological and ecological factors affect otolith shape and growth (Lombarte et al. 2003) which are recorded in their microstructures (Cardinale et al. 2004).

The kingsoldier bream (*Argyrops spinifer*) is a commercial sparid fish, living in coastal waters up to 100 m depths (Randall et al. 1997) and distributed from southern Africa to northern Australia, including the Persian Gulf (Randall 1995). Age determination in sparid species is difficult due to their thick and opaque structure. This difficulty is also associated with stacking of annuli towards the aging structure (i.e., otolith) edge, especially in older fish (Van der Walt & Beckley 1997). Several works have been carried out about age estimation using otolith on other perciforms (e.g., Francis et al. 1993; Echeverria 1987; Metin & Ilkyaz 2008; Ilkyaz et al. 2011). Because of the above reasons and lack of information on using otolith for age determination in

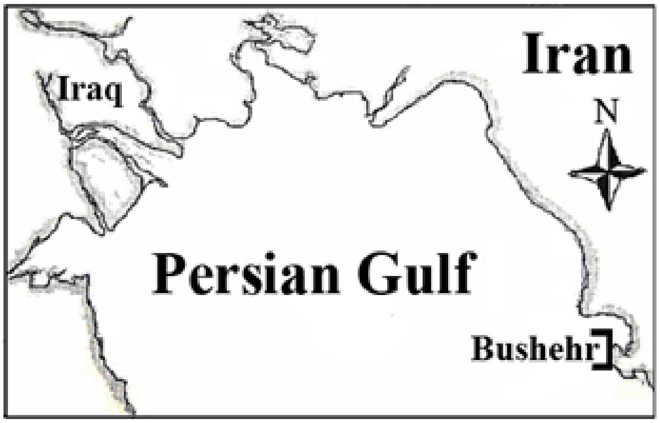

Fig.1. Study area of *Argyrops spinifer* in Bushehr coastal waters, northern Persian Gulf.

Argyrops spinifer in Iranian waters of the Persian Gulf, the objective of this study was to estimate the age of the this fish using otolith in the coastal waters of Bushehr Province in the northern Persian Gulf.

Materials and methods

Fifty-four kingsoldier bream specimens were captured along Bushehr coasts (Iran), the common fishing ground in the region which extends from 27°14′ to 30°16′ N and 50°6′ to 52°58′E (Fig. 1), from June 2010 to May 2011. Collected individuals were transferred to the laboratory on ice. Total length (TL) of each specimen was measured to the nearest 0.1cm and the sagitta otoliths were removed, cleaned and stored dry in code-numbered envelopes. The otolith length (OL) was measured by a digital caliper to the nearest 0.01mm and otolith weight (OW) was measured with a digital scale to the nearest 0.01g. The age was determined using otoliths. To increase the viewing clarity, otoliths were polished with sandpaper and immersed in a solution of glycerin and read under a stereomicroscope using reflected light. Counts of annuli for each specimen were made on the posterior part of the otoliths by two independent readers. Only coincident readings were accepted. To evaluate the precision of age determinations, a subsample of otoliths were sectioned and viewed. The results did not show differences between the two reading methods, thus age was estimated from the whole otoliths.

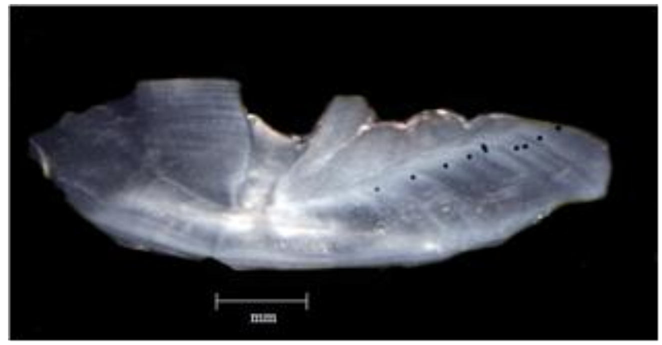

Fig. 2. A general view of *Argyrops spinifer* otolith (*TL*=45.2cm, *OL*=13.2mm, *OW*=0.30g, t=10 years). Black dots show the annuli, scale bar=1mm.

Statistical analyzes were performed in (SPSS, version 18) and by linear and non-linear regression correlations. The linear equation y=ax+b was used for estimation of the fish total length and otolith weight relationship. The relationships between fish age and otolith length, fish age and otolith weight and fish total length and otolith length were described using $y=ax^2$ equation.

Results

A general view of a sectioned otolith is shown in Figure 2. The distance between bands became smaller from the core towards the outer margin of the otoliths. According to our measurements, age of *A. spinifer* ranged between 2 and 25 years.

The specimens total length ranged between 15.1-64.2 cm (33.77±13.35). The average length of the otoliths was 10.71±2.77 mm and the average weight was 0.17±0.10 g. The relative average of otolith weight to fish total length was calculated as 0.005 (Table 1).

Table 1. Age, total length (TL; cm), otolith length (OL; mm), and weight (OW; g) of the 54 studied specimens of *A. spinifer*.

	Min.	Max.	Mean±SD	Variance
Age	2	25	7.65 ± 5.55	30.80
TL	15.1	64.2	33.77 ± 13.35	178.31
OL	5.77	18.2	10.71 ± 2.77	7.66
OW	0.05	0.51	0.17 ± 0.10	0.011
OW/TL			0.005	

A linear relationship between fish total length and otolith weight was estimated as

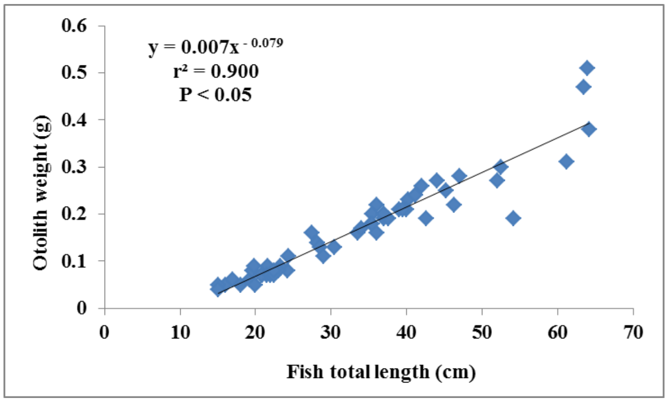

Fig. 3. The relationship between fish total length and otolith weight in *Argyrops spinifer*.

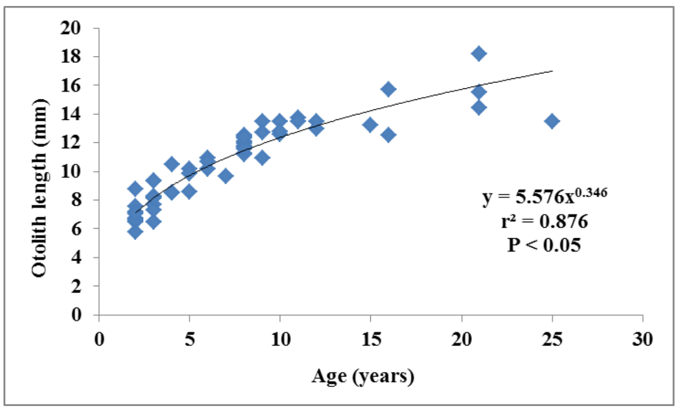

Fig. 4. The relationship between fish age and otolith length in *Argyrops spinifer*.

$OW=0.007TL^{0.79}$ ($r^2=0.90$) (Fig. 3). The relationship between fish age and otolith length was as $OL=5.576 (t)^{0.346}$ ($r^2=0.87$) (Fig. 4). Also, there was a strong relationship between fish age and otolith weight as $OW=0.031 (t)^{0.837}$ ($r^2=0.91$) (Fig. 5). The relationship between fish total length and otolith length was described as $OL=1.125 (TL)^{0.644}$ ($r^2=0.91$) (Fig. 6). There were strong correlations between these parameters ($P<0.05$) in this species.

Discussion

The age of the kingsoldier bream specimens using otolith was estimated between 2 and 25 years. Al Mamry et al. (2009) in their study in the Arabian Sea estimated the age of this species as up to 25 years. They cut one otolith from each specimen and age was determined from the annual rings. The maximum reported absolute age for this species in the southern Persian Gulf which was reported by

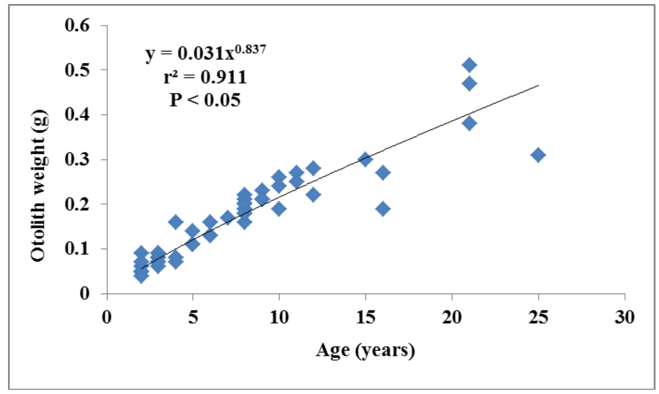

Fig. 5. The relationship between fish age and otolith weight in *Argyrops spinifer*.

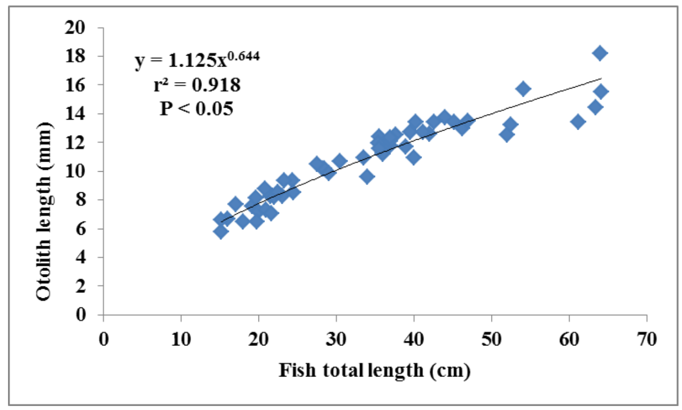

Fig. 6. The relationship between fish total length and otolith length in *Argyrops spinifer*.

Grandcourt et al. (2004) is 9.1 years. They used the same method as Al Mamry et al. (2009) for age determination. El-Sayed & Abdel-Bary (1995) used the scale reading methods for age determination and reported the maximum life span of this species as 20 years in the southern Arabian Sea and considered it as a long-lived fish. The differences between Grancourt's study, our study and the two other studies could be related to changes in seawater temperature and biological productivity in the coastal waters of these different regions.

The process of otoliths growth provides important information for ageing and growth of fishes. Many researchers emphasized the close relationship between the fish total length and otolith weight (Smith & Deguara 2002; Metin & Ilkyaz 2008) and also between the age of the fish and their otolith weight (Anderson et al. 1992; Smith & Stewart 1994). So they relied on the potential use of

these relationships in age determination. This might be because of the continuous and steady rate of mineral deposition on otoliths (Fletcher 1991) or the decrease of the longitudinal growth after maturity (Nedreaas 1990). In older age groups, growth of the fish and linear growth of the otoliths decreases, but due to the deposition of minerals on the otoliths, after the growth halts, diameter of the otolith increases regularly (Nedreaas 1990). The result of this process is the halt of otolith lengthening and increasing of otolith weight in older fish. With respect to the strong relationship between fish total length and otolith weight, the estimation of the total length of the kingsoldier bream based on the otolith weight is highly reliable.

The higher correlation coefficient of the equations indicates that the relationship between fish age and otolith weight is stronger than that of the fish age and otolith length. Brander (1974) hypothesized that there is a direct relationship between otolith weight and age of fishes. Spratt (1972) expressed that fish sampled from slowly growing populations have larger otoliths relative to their size when compared to fish of the same length. More recently, several researchers found a strong relationship between the fish age and otolith length and weight (Metin & Ilkyaz 2008; Ilkyaz et al. 2011). Cardinale et al. (2000) found a strong relationship between otolith weight and age in *Pleuronectes platessa* and *Gadus morhua*, and recommended this technique since it is objective, economical, and easy to perform in age determination.

There is a strong relationship between fish length and otolith length ($r2=0.92$) in the kingsoldier bream, as reported in other species (Harkonen 1986, Smith & Robertson 1992, Metin & Ilkyaz 2008). Gauldie (1988) stated that the strong relationship between the fish length and otolith length is due to the fact that both of them follow the same metabolic processes. Casselman (1990) stated that the comparative size of calcified structures is a sensitive indicator of growth. Based on this close relationship, it is possible to use the von Bertalanffy growth equation in explaining the relationship between otolith length and fish age as it is used in explaining the relationship between fish length and age. Based on Wilson (1984), Secor & Dean (1986) and Pawson (1990), relative average of otolith weight to fish total length is a typical indicator of fish growth and fishes with higher ratio of otolith weight to fish total length have a slower growth rate.

The applicability of strongly correlated relationships between fish length and otolith weight, between otolith length and fish age, between otolith weight and fish age and between fish length and otolith length was investigated and it was concluded that the relationship between fish length and otolith length and also the relationship between otolith weight and fish age were stronger than other relationships. Therefore, they are the best for age determination of the kingsoldier bream and practically and easily could be used with a lower error rate.

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